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Research Article

Graphical Reasoning in Nepal's High School Mathematics

Santosh Pathak[*1] and Eeshwar Prasad Poudel[2]

[1]Department of Mathematics, University of Utah Asia Campus, Incheon, Republic of Korea
spathak2039@gmail.com
[*2]Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal
eeshwarpoudel475@gmail.com

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Abstract

Graphical reasoning plays a crucial role in helping students grasp mathematical ideas, particularly those involving functions, calculus, and their applications in science. Yet in Nepal, this aspect of mathematics education is widely underdeveloped. This article analyzes the current situation in Nepal's high school mathematics system, examining how curriculum, teaching practices, and assessments neglect graphical learning. Drawing on research, observations, and comparative insights, it highlights the systemic issues that undermine students' conceptual understanding and proposes practical steps to bring about reform. The article makes the case for a stronger emphasis on visual reasoning, supported by thoughtful curriculum design, better teacher preparation, appropriate use of technology, and meaningful testing.

Keywords: Functions and their Graphs; Representations of Function; Mathematics in Nepal.

AMS(MOS) Subject Classification: 97Bxx; 97Cxx

1 Introduction

Many students in Nepal struggle not only with graphing but with mathematics as a whole. Nepal's education system has deep historical roots in traditional *Gurukula* learning, but was later shaped by Indian and British influences. A formal, state-run education system was established only after the advent of democracy in 1951 [39], with the first national curricula introduced in 1971. Since then, access and structural organization have improved, but content and pedagogy—especially in mathematics—have lagged behind international

*Corresponding author

standards. The Curriculum Development Center (CDC) and the National Examination Board (NEB) currently oversee curriculum and testing, yet intense pressure on schools to perform well on standardized exams has contributed to an overly exam-focused education culture [5]. A 2020 report by the National Assessment of Students Achievement (NASA), published by the Education Review Office (ERO), found that students continue to struggle to meet minimum learning objectives [24]. According to the report, the national average for mathematics in 2020 dropped by 17 scale points compared to 2017 [23], and similar gaps exist in other subjects. Nepal's global ranking in mathematics remains low [26].

Functions are widely regarded as foundational in mathematics [32], with Dubinsky [9] calling them "the single most important idea in all of mathematics." Their dual representations—algebraic and graphical—are symbolically distinct but conceptually linked. Teaching them in isolation can hinder understanding, as each reinforces the other's meaning. This duality forms a "bridge" that works differently depending on direction, yet students often struggle to transfer knowledge across forms [11], [12], [14], [15], [20]. Graphical literacy, emphasized by Shuard and Neill [25], is essential in both math and science, where graphs serve as both descriptive and predictive tools. While international research supports the importance of visual representations [3], [11], [12], [15], [20], in Nepal, these aspects remain under-emphasized in instruction, curricula, and assessments.

2 Objective

This study investigates the persistent challenges faced by Nepalese high school students in developing a graphical understanding of mathematics. Situated within the broader curricular and pedagogical context, it examines how Nepal's exam-driven education system—shaped by traditional and colonial legacies—continues to fall short in achieving meaningful learning outcomes [5], [27], [28], [29], [36], [39]. As a result, students often develop only a weak conceptual foundation in functions and their graphical representations.

Drawing on cognitive and educational research, this study emphasizes the representational complexity of functions in mathematical learning [8], [11], [12], [14]. Through an analysis of curricular practices and insights from the authors' cross-cultural teaching experience, the research aims to identify structural and pedagogical barriers to graphical literacy and propose actionable strategies to improve function-based learning in Nepalese classrooms.

3 Method

This study employed a qualitative, descriptive approach to investigate the challenges in developing graphical understanding within Nepal's high school mathematics system. The research was grounded in an analysis of curricular, and pedagogical contexts to understand how Nepal's exam-focused education system contributes to weak conceptual grounding in functions and their graphical representations.

3.1 Data Sources and Review

The primary data sources for this study included:

Curriculum Documents: A careful review of the current mathematics curricula for grades 9-12 was conducted to identify the stated learning objectives related to functions, graphing, calculus, and differential equations. Specific attention was paid to the clarity and specificity of graphical learning outcomes, as well as the distribution of graphing content across grade levels.

National Examination Papers: Final examination papers for grades 10, 11, and 12 from the past several years (specifically, nine years for grade 11 and 12 exams) administered by the National Examination Board (NEB) were reviewed. The analysis focused on the frequency and nature of questions requiring graphical reasoning, sketching, or interpretation, particularly concerning quadratic, cubic, trigonometric, exponential, logarithmic, and rational functions, as well as calculus and differential equations concepts.

Observations and Teaching Experience: The authors' cross-cultural teaching experience in Nepal, including a specific instance during the 2019–2020 academic year where the grade 11 mathematics curriculum was split among three teachers, provided direct observational insights into classroom practices, teaching culture, and the challenges of fragmented instruction.

Existing Research and Comparative Insights: The study drew on existing research in cognitive psychology, and educational psychology [8], [14] regarding teaching and learning, specifically focusing on the representational complexity of functions in learning [12], [15], [20]. A brief comparative insights from mathematics education in the United States, particularly regarding the distribution of graphing content and the emphasis on visual representations, were also utilized.

4 Graphical Reasoning in the Curriculum

4.1 Lack of Clarity and Graphical Content in Learning Outcomes

A careful review of the current curricula for grades 9–12 reveals both a lack of specificity in learning objectives and a notable absence of graphical content, particularly in higher-level mathematics topics. For instance, although identifying the domain and range of functions is listed as a goal in grades 9 through 11, the syllabi do not clarify whether students should determine these characteristics from graphs, tables, or algebraic expressions—thus missing essential connections between representations.

In grade 11, the section on curve sketching includes various function types—trigonometric, polynomial, exponential, logarithmic, and rational—but omits whether students should explore transformations such as shifts and reflections. Textbooks sometimes include "simple cases" of graphing, but without a clear definition of "simple", this leads to inconsistencies in instruction and assessment. Even more concerning is the Calculus unit, which comprises 30% of the academic year yet makes no explicit mention of graphing in its learning outcomes. Critical visual concepts such as:

- Interpreting left- and right-hand limits from a graph
- Evaluating infinite limits and end behavior using graphs
- Sketching graphs using limits and continuity
- Graphical understanding of increasing/decreasing behavior
- First derivative test using graphical justification
- Transitioning between graphs of f and f'

$\cdots$ are completely absent from the syllabus. The grade 12 curriculum continues this pattern. Despite covering advanced calculus topics, it fails to include visual understanding or graphing in its learning goals. Notable omissions include:

- Graphical interpretation of continuity and differentiability
- Application of L'Hospital's Rule for comparing growth rates
- Visual relationship between hyperbolic and exponential functions

This lack of graphical emphasis is especially evident in the treatment of differential equations, introduced in grade 12. While students learn standard solution methods (e.g., separable variables, linear and exact equations), the curriculum neglects intuitive and visual aspects such as:

- Understanding exponential growth/decay, proportionality, doubling time, and half-life in population models
- Graphical interpretation of decay constants and growth curves
- Applications in real-world contexts (biology, chemistry, physics, engineering)

In sum, the curriculum's narrow focus on symbolic procedures, coupled with the omission of graphical and conceptual learning outcomes, limits students' ability to develop a deep, flexible understanding of mathematics.

4.2 Imbalanced Distribution of Graphing Content

Unlike in the United States—where high school students have the flexibility to take advanced mathematics courses like Pre-Calculus, Calculus, or even university-level classes—Nepal's high school education system lacks such opportunities. This inflexibility makes it all the more important to ensure that graphing content is thoughtfully and effectively integrated across grade levels.

Currently, the distribution of graphing instruction in Nepal's curriculum is quite limited:

- Grade 9's elective mathematics contains no graphing objectives.
- Grade 10 includes limited graphing (basic $y = \sin x, y = \cos x$, and $y = \tan x$ for $-2\pi \leq x \leq 2\pi$ and quadratic: $y = ax^2$ and cubic functions: $y = a(x - b)^3$).
- Grade 11 introduces a very broad range of functions for graphing, yet only allocates about 6% of the year's teaching time to this topic.
- Grade 12 excludes graphing altogether, with no tasks requiring graphical or visual reasoning.

This limited and uneven integration of graphing across grade levels makes it difficult for students to gradually build confidence and fluency in visual mathematical reasoning.

4.3 Insufficient Graphing of Trigonometric Functions

Trigonometry plays a central role in high school mathematics, connecting algebraic, geometric, and graphical reasoning. The graphs of trigonometric functions are particularly important in fields such as physics, architecture, and engineering [1], [37]. Yet in Nepal's curriculum, the development of graphical understanding of trigonometric functions is seriously underemphasize.

- Grade 9 introduces trigonometric identities but does not include any graphing of trigonometric functions or their geometric interpretations (beyond the Pythagorean identity).
- Grade 10 requires students to graph only the basic forms of $y = \sin x, y = \cos x$, and $y = \tan x$ over a limited domain and without transformations (shifts, stretches, reflections).

- Grade 11 briefly touches on amplitude, periodicity, and even/odd nature of these functions in the curve sketching unit (again only 6% of total instruction time).
- Grade 12 does not include any graphing of trigonometric or inverse trig functions, despite their introduction in symbolic form.

This curriculum structure means that students often complete high school without ever encountering or graphing generalized trigonometric functions such as: $f(x) = \sin \frac{\pi(x-h)}{b}$, which are foundational to understanding transformations, wave behavior, and applied modeling.

5 Classroom Practices and Teaching Culture

A comparison between the current state of mathematics education in Nepal and that described by Lardner in 1965–66 [19] shows that progress has been slow, especially in aligning with global standards. Challenges fall into two broad categories: systemic factors (social, political, economic, cultural, and geographic) and academic issues like curriculum, textbooks, teaching, and assessment [5]. While curriculum and testing are discussed in other sections, this section focuses on teaching—particularly the limited integration of graphing and graphical reasoning in high school math. Many students reach university without a solid grasp of functions and their graphs, not due to a lack of exposure, but because of ineffective teaching [10]. Even with prior instruction, students often lack conceptual understanding [20]. In Nepal, poor teaching practices hinder students' ability to learn graphical concepts, leaving gaps that become evident in higher education, especially abroad. Below, we outline two critical areas of concern in teaching.

5.1 Fragmented and Unusual Teaching Culture

One particularly problematic feature of the Nepali system is the practice of dividing a single mathematics course across multiple instructors. In grades 11 and 12, the curriculum is both content-heavy and assessment-driven due to the centralized final board examinations of grade 12. Schools are under pressure to complete the syllabus within a fixed time-frame and to ensure high passing rates—especially private institutions, which often use exam results as a marketing tool.

To manage this pressure, many schools (primarily in urban areas, where access to qualified mathematics teachers is generally higher than in rural regions) divide the mathematics syllabus into two or more parts and assign different teachers to teach them concurrently. On any given day, students might attend classes taught by multiple instructors covering entirely different portions of the same course. This creates severe sequencing issues in instruction and leads to significant gaps in prerequisite knowledge. The lack of coordinated pacing among teachers results in conceptual discontinuity that undermines students' ability to build connections across topics.

For example, at a well-known school in Kathmandu, Nepal, during the 2019–2020 academic year, the grade 11 mathematics curriculum was divided among three teachers, as shown below:

Table 1: An instance of contents allocation of grade 11's mathematics course to three different teachers.

Teacher A	Teacher B	Teacher C
Sets, Real Numbers	Matrices and Determinant	Limits and Continuity
System and Logic	System of Linear Equations	The Derivatives and its Applications
Relation, Functions and Graphs	Complex Numbers	Antiderivatives and its applications
Sequence and Series	Polynomials	Curve Sketching
Mathematical Induction		

One clear instructional issue arises when, for example, Teacher C begins teaching limits of exponential or logarithmic functions using identities such as $\lim_{x\to 0}\frac{\log(1+x)}{x} = 1$ and $\lim_{x\to 0}\frac{e^x-1}{x} = 1$ while Teacher A has not yet introduced exponential or logarithmic functions or their graphs. In one such instance, when Teacher C wrote the exponential function on the board, students immediately asked, "Sir, what is an exponential function?" This disconnect clearly demonstrates the consequences of uncoordinated instruction. Similarly, a teacher may be required to introduce derivatives of inverse trigonometric functions before students have even encountered these functions or their domains, much less their graphs. Teaching the derivative of $y = \sin^{-1} x$ for example, requires domain restrictions and a graphical understanding of inverse functions—none of which may have been covered. Teachers are then left to present critical identities like $\lim_{x\to 0}\frac{e^x-1}{x} = 1$ without the foundational knowledge students need to comprehend or appreciate them, forcing rote memorization in place of conceptual understanding.

5.2 Lack of Technology Integration in Teaching

Technology—such as function plotters and computer algebra systems—has transformed mathematics education globally by making complex concepts more accessible through visual representations [4], [13]. These tools support deeper student engagement, even for those with weaker algebra skills. However, over-reliance on technology without linking visual outputs to algebraic reasoning can lead to shallow understanding, making conceptual instruction essential [33].

In Nepal, the integration of graphing technology in high school mathematics is minimal. Most teachers lack both training and access to necessary tools, and the curriculum does not promote their use. Limited infrastructure—such as insufficient computers and internet—further hinders effective implementation.

A common question in the "Application of Derivatives" unit in grade 11 involves analyzing the function $f(x) = x + 1/x$ often using the first or second derivative tests. However, the curriculum provides little prior exposure to graphing rational functions, leaving students unprepared for visual analysis. In typical classrooms, teachers tend to bypass graphing entirely and proceed directly with algebraic tests—failing to reinforce understanding through visualization. With the help of a graphing tool, the plot of $f(x) = x + 1/x$ as shown in Figure 1 offers immediate insight into the function's behavior. It allows students to verify their derivative-based conclusions graphically and fosters a deeper, more intuitive understanding of the function's local and global behavior. Another commonly used identity in the calculus curriculum is: $\lim_{x\to 0} \sin x/x = 1$. Visualizing the function $f(x) = \sin x/x$ can significantly enhance students' comprehension of this limit. As illustrated in Figure 2, the graph provides insight into the limit's meaning and helps cultivate students' curiosity and appreciation for the underlying mathematical structure.

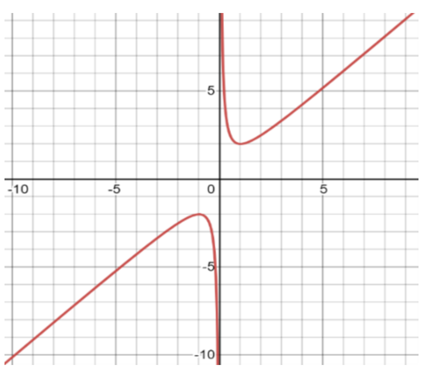

Figure 1: Graph of $f(x) = x + 1/x$

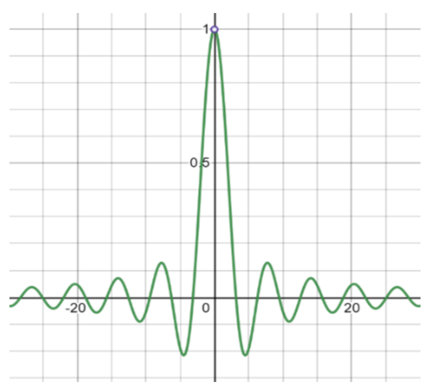

Figure 2: Graph of $f(x) = \sin x/x$

These examples represent just a few of the many instances where technological tools could greatly enhance conceptual understanding in high school mathematics. In addition, technologically generated graphs can be used effectively to:

- Illustrate the connection between roots, intercepts, and turning points in polynomial functions
- Demonstrate the Leading Coefficient Test and the end behavior of higher-degree polynomials

- Visualize domain, range, asymptotes, periodicity, parity (even/odd functions), and removable discontinuities (holes)

- Graph functions commonly encountered in calculus, including exponential, logarithmic, rational, and trigonometric forms

- Explore limits, continuity, local/global extrema, and areas between curves

Despite these powerful capabilities, such approaches remain virtually unused in most Nepali high school classrooms. Until curricula formally include and encourage the use of technology, and until educators are trained in its pedagogical integration, students in Nepal will continue to miss out on crucial opportunities for developing graphical intuition and deeper mathematical insight.

5.3 Extremely Exam-Oriented Teaching

High school mathematics in Nepal is heavily shaped by an exam-centric culture, where instruction, pacing, and textbooks are guided by anticipated exam content. From the beginning of the school year, students rely on compilations like *Question Banks* or *Old is Gold*, which strongly influence teaching strategies. Research shows that this focus narrows instruction, prioritizing procedural tasks over conceptual understanding and visual reasoning [7], [29].

As a result, essential areas like graphing are often neglected. Functions such as $\sin x/x$ and $\log x/x$, which require interpreting intercepts, discontinuities, and end behavior, are included in the curriculum but seldom practiced, as graphing tasks are absent from national exams. This disconnect leads to superficial or skipped coverage in classrooms.

Even when teachers attempt to include graphing, students may resist, viewing it as irrelevant to exam success. This attitude is reinforced by a system that values test performance above all else [7]. For instance, although Grade 10 outcomes mention graphing basic trigonometric functions like $y = \sin x$, such tasks have never appeared on the Secondary Education Examination (SEE), leading teachers to omit them in favor of algebraic topics [18], [29].

This exam-driven model limits the development of higher-order skills like visual reasoning and conceptual transfer—key components of meaningful mathematical learning [2], [18]. Without intentional reforms in curriculum, assessment, and teacher training, students will continue to graduate lacking essential mathematical competencies beyond what standardized tests measure.

6 Assessment and Testing

In education, testing serves various purposes—from evaluating student performance and assigning grades to diagnosing and predicting future learning outcomes. As Roediger and other [31] note, well-designed tests can enhance learning, not merely measure it. School tests are broadly categorized as prognostic or diagnostic. Prognostic tests assess students' aptitude early to forecast future performance. Diagnostic tests, more familiar to teachers, evaluate progress during or after instruction. Reeve [30] further divides diagnostic tests into two types: those developed by external agencies unfamiliar with the teaching context and those created by course instructors. Nepal's National Examination Board (NEB) represents the former, designing standardized end-of-year exams for grades 10 and 12 (previously including grade 11). While such external assessments can be effective in theory, their value depends on how well they reflect curricular goals. In Nepal, these exams often neglect key learning outcomes—especially graphical understanding—which, though included in the curriculum and textbooks, are rarely tested. Below, we highlight two major issues in Nepal's high school mathematics exams regarding their assessment of graphical concepts.

6.1 Insufficient Testing on Graphing

A review of grade 10 and 11 final examinations over the past several years reveals a glaring under representation of graphing tasks. For example, questions requiring students to sketch the graph of a quadratic function, such as $y = ax^2 + bx + c$, have appeared sporadically and never constitute more than 4% of the exam's total weight. Although the curriculum includes learning outcomes for graphing trigonometric functions $y = \sin x$, $y = \cos x$, $y = \tan x$,cubic functions $y = ax^3$, these have never been tested in the SEE (Secondary Education Examination). As a result, these topics are largely neglected in both teaching and learning.

In grade 11, the situation is similar. Questions on functions are typically split between two types: (1) identifying characteristics such as symmetry, parity (even/odd), or periodicity, and (2) sketching the graph of a function. However, these are treated as completely disconnected tasks. For example, students may be asked to analyze properties of a polynomial in one question and then sketch an unrelated function in another. This compartmentalized approach reflects the format of national exams and reinforces the notion that conceptual connections—such as how symmetry affects graph shape—are unimportant. A review of Grade 11 exams over the past nine years indicates that:

- Graphing of quadratic functions appeared six times.
- Graphing of exponential functions appeared once ($y = 1/3^x$).
- Graphing of trigonometric functions appeared once ($y = 3 \sin x$).

- Graphing of cubic functions appeared once ($y = (x-1)^3$).
- Graphing of logarithmic and rational functions never appeared.

This clearly signals to both teachers and students that these function types can be safely ignored, despite being explicitly listed in the curriculum.

In Grade 12, the neglect of graphical concepts is even more pronounced. A review of the past nine years of exams revealed that not a single question required students to graph a function. Despite the curriculum covering advanced topics—including functions in calculus and differential equations—these are entirely absent from the assessments, effectively discouraging the teaching of graphical concepts at this level.

6.2 Systematic Avoidance of Graphical Reasoning in Assessment Design

A more troubling pattern in secondary mathematics education is the systematic avoidance of graphical reasoning, even when it is pedagogically natural or conceptually essential. In Grade 10, for instance, students routinely solve cubic polynomial equations but are seldom asked to connect roots with x-intercepts, examine turning points or inflection points, analyze end behavior, or apply the Leading Coefficient Test.

For topics like limits and continuity, students are expected to compute expressions such as:

$$\lim_{x\to\infty} \frac{3x^2-4}{4x^2}$$

but they are rarely asked to interpret such limits graphically—for example, by identifying horizontal asymptotes.

In Grade 11 calculus, which comprises approximately 30% of the syllabus, graphical reasoning is almost entirely absent from assessments. Over the past nine years of national examinations, not a single question has required students to sketch or interpret the graph of a function. Instead, the focus remains on algorithmic and symbolic problems, such as:

- Use integration by parts to evaluate $\int (x^2+1)e^x\,dx$.
- Solve abstract limit or derivative problems, such as finding $\lim_{x\to 0} \frac{e^x - x - 1}{x^2}$.
- Find, from first principles, the derivative of $\log(\sin x)$.

Even when visual reasoning might enrich conceptual understanding, students are allowed to choose between problems—one graphical, one not—and most opt to avoid graphs altogether. This preference is a direct consequence of how assessments are designed. For instance following are the problems appeared on the past exams of grade 11 or 12.

Question-1 Evaluate: $\int (x^2 + 1)e^x \ dx$
Or
Find the area bounded by the x-axis and the curve $y = (x + 1)(x - 2)(x - 3)$.

Question-2 State Rolle's Theorem. Interpret it geometrically. Verify Rolle's Theorem for the function $f(x) = (x - 1)(x - 2)(x - 3)$.
Or
Find, from the first principle, the derivative of $\log \sin x$.

In both questions, students can choose the option that requires no graphical understanding. This highlights a systemic flaw in assessment design that discourages the development of graphical reasoning skills.

Furthermore, the following examples from the Grade 12 curriculum illustrate how graphical reasoning is consistently avoided in assessments.

- L'Hôpital's Rule is routinely tested using symbolic expressions like $\lim_{x \to 0} \dfrac{\tan x - x}{x - \sin x}$, but never by visually comparing the growth rates of exponential, logarithmic, and polynomial functions.
- Differential equations are examined purely through symbolic manipulation, with no questions involving slope fields or sketching solution curves.
- Despite conceptual overlap, hyperbolic and exponential functions are never connected graphically.

Current exams miss valuable opportunities to pose integrated questions that assess multiple skills. For example, for the function $f(x) = (x - 1)(x - 2)(x - 3)$, students could be asked not only to find roots but also to:

- Identify intercepts, turning points, and end behavior,
- Relate the shape to the polynomial's degree and leading coefficient,
- Sketch the graph.

Figure 3 shows the graph of a typical cubic polynomial. Despite having learned how to identify roots, turning points, and inflection points algebraically, students are rarely tested on their ability to connect these features to deduce its algebraic equation. As a result, their conceptual understanding remains shallow. A better question from a testing point of view would have been:

Improved Graph-Based Question

Question: Answer the following based on the graph of a cubic polynomial which is given alongside.

- Identify intervals of increase/decrease and concavity.
- Locate local maxima and minima.
- Find real zeros and note any multiplicities.
- Write the intercepts in ordered pair form.
- Write the polynomial in factored form.

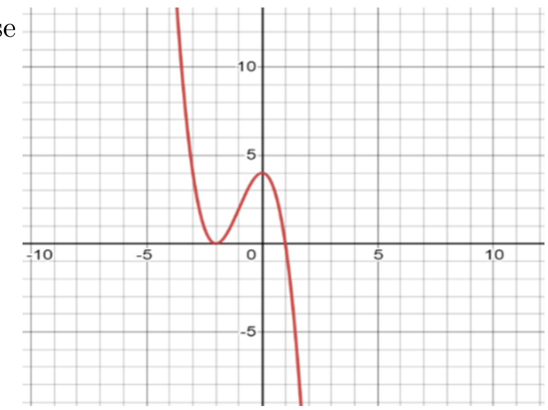

Figure 3: Graph of a Polynomial Function

Such questions assess students' representational fluency, especially the ability to derive algebraic equations from graphs. Studies show that students often struggle to connect algebraic and graphical forms—while many can manipulate symbols, they find it difficult to interpret or construct corresponding graphs [21], [38]. Converting from graph to equation is particularly challenging, as it demands conceptual understanding beyond procedural skill [38]. Despite their importance, such question types are notably absent from Nepal's assessment design.

Also, grade 11 and 12 contain a component called "practical and project activities" as part of the assessment process, where students are required to work under the guidance of a teacher on a selected topic. This internal assessment constitutes 25% of the total grade. However, a careful review of the list of 15 suggested topics drawn from various mathematical areas shows that none of them aim to enhance students' graphical or visual reasoning. This omission reflects the same pattern seen throughout the curriculum—graphing and visualization are consistently undervalued in both instructional content and assessment design.

7 Discussion of the Results

The study reveals major shortcomings in Nepal's high school mathematics education, particularly in the development of students' graphical reasoning. Despite the foundational role of functions and their visual representations [11], the national curriculum lacks clear, graph-specific learning outcomes. Graphing is introduced inconsistently and often too late, especially in calculus and differential equations, where visual understanding is crucial [20].

Classroom instruction suffers from fragmented teaching and poor sequencing, as different teachers cover disconnected topics without coordination. Students frequently encounter advanced graph-based topics without having first learned the necessary foundations. This disconnect forces reliance on rote procedures instead of conceptual understanding. Technology, though widely used elsewhere to enhance mathematical insight [13], [33] is virtually absent in Nepali classrooms due to infrastructure gaps and lack of teacher training. Even where graphing tools could greatly aid understanding, they remain unused.

Most critically, Nepal's exam-oriented educational culture—which is already struggling to achieve satisfactory outcomes [29]—actively discourages the teaching of graphing skills. Because national examinations seldom assess graphical reasoning, both teachers and students tend to deprioritize it, even when it is explicitly included in the curriculum. As a result, many students graduate without developing essential visual and analytical competencies, leaving them underprepared for further study in STEM disciplines.

In sum, without changes to curriculum, pedagogy, and assessment, students will continue to miss out on the deep conceptual benefits of graphical reasoning.

8 Implication

The findings of this study have several important implications for mathematics education policy, curriculum development, teacher training, and classroom practice in Nepal.

8.1 Curriculum

The persistent absence and underemphasis of graphical content across grades 9–12 call for a revision of the national mathematics curriculum. Learning outcomes should explicitly require students to interpret, construct, and analyze graphs of various functions—including polynomial, rational, exponential, logarithmic, and trigonometric forms. Additionally, key calculus concepts such as limits, continuity, and derivatives must be tied to their graphical interpretations to build deeper conceptual understanding [16], [17].

8.2 Teacher Training

Many teachers lack the necessary training to effectively incorporate graphical reasoning into their instruction [2]. This research underscores the urgent need for professional development that emphasizes multiple representations of mathematical concepts, particularly through the use of dynamic visual tools and concept-driven teaching strategies. Teacher education should integrate both theoretical foundations and practical experience in using graphing technology and designing lessons that build connections between algebraic and graphical representations [34]. Additionally, training programs should include Duval's ([11], [12])framework on representational transformations to better prepare teachers to support students who struggle with shifting between different forms of mathematical thinking.

8.3 Technology

Nepal's mathematics classrooms remain largely untouched by graphing software, dynamic geometry environments, or computer algebra systems. To modernize instruction and support student learning, infrastructure must be improved, and policies should actively encourage the use of technology. Even in low-resource settings, simple, free tools (such as Desmos or GeoGebra) can substantially enhance students' ability to explore and understand complex functions visually [4].

8.4 Assessment

Current national examinations almost entirely neglect graphical reasoning, sending a clear signal to teachers and students that such skills are not valued. To realign assessments with curricular intentions and global best practices, exams must include graph-based tasks that test interpretation, sketching, and conceptual reasoning. Integrated, multistep questions should encourage students to make meaningful connections across representations and problem contexts [6], [22], [35].

8.5 Exam-Oriented Culture

Research shows that exam-centric teaching culture undermines efforts to promote deeper understanding [27], [36]. Schools, policymakers, and curriculum developers must work together to shift the focus from rote memorization and test preparation to meaningful learning. This includes rethinking textbook design [28], encouraging exploratory tasks, and valuing conceptual clarity over procedural speed.

9 Concluding Remark

In conclusion, the neglect of graphical reasoning in Nepal's high school mathematics curriculum, instruction, and assessment represents a serious barrier to meaningful mathematical understanding. Without deliberate reforms—such as clearer curricular goals, improved teacher training, technology integration, and better-aligned assessments—students will continue to rely on rote procedures while missing out on the powerful visual tools that make mathematics intuitive, applicable, and engaging. Addressing these issues is essential for raising national standards and preparing Nepalese students for success in higher education and beyond.

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